Engine

Service Manual - Side Engine Loadalls

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Technical Data

JCB Dieselmax

Engine Specifications

Engine variants	SA	Naturally aspirated	63 kW (85 bhp)
	SB	Turbocharged	74 kW (100 bhp)
	SC	Turbocharged with intercooler	93 kW (125 bhp)
Weight (dry)	SA	472 kg (1040 lb)	
	SB	477 kg (1052 lb)	
	SC	477 kg (1052 lb)	
Number of cylinders	4		
Nominal bore size	103 mm (4.05 in)		
Stroke	132 mm (5.196 in)		
Cylinder arrangement	In line		
Cycle	4 stroke		
Firing Order	1, 3, 4, 2 - Number 1 cylinder at crankshaft pulley end		
Displacement	4.4 litres (268.5 in^3)		
Compression ratio	SA	18.6 : 1	
	SB	18.3 : 1	
	SC	17.5 : 1	
Direction of rotation (viewed from crankshaft pulley end)	Clockwise		
Valves	4 per cylinder		
Valve tip clearances (measured cold)	SA, SB, SC	Inlet: 0.19 mm to 0.27 mm (0.0075 in to 0.0106 in)	
		Exhaust: 0.56 mm to 0.64 mm (0.022 in to 0.252 in)	
Lubricating oil pressure (1)	SA, SB, SC	4.0 to 4.8 bar (58 to 70 lbf/in^2)	
Combustion system	Direct injection		
Fuel injection pump	SA, SB, SC	Rotary mechanical	
Idle speed	SA, SB, SC	900 rpm	
Recommended fuel specifications	Refer to ***Section 1, - General Information, Diesel Fuel***		
JCB Engine Service Manual	SA, SB, SC	9806/3000	

(1) Engine at normal operating temperature and maximum revs.

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Circuit Descriptions

Cold Start Heater - SA, SB, SC Engines

This section explains how the cold start electrical system works.

The system aids engine starting by heating the air in the induction manifold via electrical `grid heater' **A**. Operation of the system is fully automatic and is controlled by ECU **CA**. Ambient air temperature sensor **CC** enables the system when air temperature is less than -6°C (21°F). The heating sequence is as follows:

1 Starter key set to the ON position

2 Warning light **DH** illuminated - grid heater ON - engine not ready to start

3 After a preset `pre-heat' time the warning light **DH** extinguishes - engine ready to start (1)

4 Starter key turned to engage starter motor and start the engine - grid heater on

5 Engine started - starter motor disengaged - grid heater OFF (2)

(1) The `pre-heat' stage can not be repeated unless the starter key is first set to the OFF position.

(2) If the engine stalls and is restarted without turning the starter key to OFF, the grid heater will come on while the starter motor is engaged.

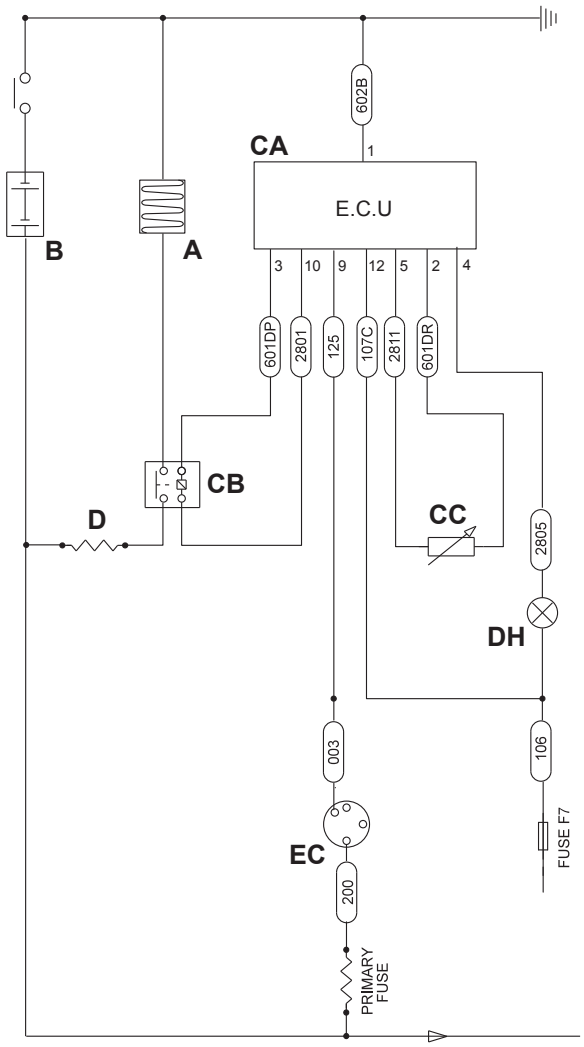


Fig 1. Electrical Schematic

Component Key:

A Grid heater

B Battery

CA Electronic control unit (ECU)

CB Relay - grid heater

CC Ambient air temperature sensor

D Primary fuse - grid heater

EC Starter switch

DH Warning light - grid heater ON - engine not ready to start

Diagnostic `Blink' Codes

Machines fitted with a cold start heater incorporate an electronic control unit (ECU). The ECU has the facility to detect faults with the cold start heater electrical system. These faults are indicated using the cold start indicator light **2A** in the instrument panel. The blink code sequence consists of the light being switched ON for approximately one second followed by a number of flashes (the code). The sequence is repeated until the fault is cleared.

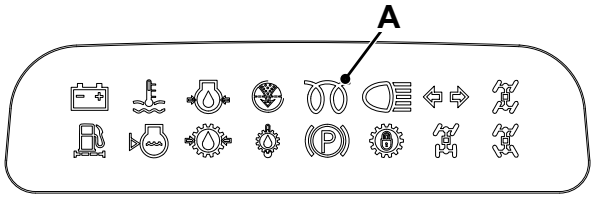
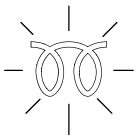


Fig 2.

Blink Code	Cause	Action
		
1 flash	Temperature sensor or circuit fault (open circuit).	Check temperature sensor (infinite resistance) related harness wires and connectors. ⇨ ***Wires and Connectors (K-7)***.
2 flashes	Temperature sensor or circuit fault (short circuit).	Check temperature sensor (no resistance) related harness wires and connectors. ⇨ ***Wires and Connectors (K-7)***.
3 flashes	Heater Relay fault.	Check related relay and related harness wires and connectors. ⇨ ***Wires and Connectors (K-7)***.
4 flashes	Heater Relay output fault (open or short circuit).	Check related relay and related harness wires and connectors. ⇨ ***Wires and Connectors (K-7)***.

Wires and Connectors

For components and connector locations ⇒ *Fig 3. (K-6)*.

Wires and connectors ⇒ *Fig 4. (K-7)*. On the electrical diagram the electrical connectors (example, CA) are shown looking on the mating face of each connector when they are disconnected.

The wire numbers and colours, where appropriate, are shown as an aid to identification whilst fault finding.

Before fault finding make sure that you understand how the electrical circuits work. Most potential faults can be traced using a multimeter to carry out continuity checks on wires, switches and solenoid coils.

Note: *When fault finding do not use a multimeter on the ECU pins. Only test the associated wiring. Uncouple the connector* ***CA*** *and then use a multimeter at the pins inside the connector as applicable. The ECU is inherently more reliable than its associated wiring and components. Before renewing the ECU be sure to check all the related equipment first.*

Earth Points

Faults may be caused by poor earth connections. For details of these connections, see ***Section C, Electrics - Machine Earth Connections***.

Component Key

The following key identifies the component connectors.

A	Grid heater
B	+ve battery connection - starter motor
D	Primary fuse
h1	Harness - 721/11975 Cold start
h2	Harness, machines upto 10.5 lift height - 721/11879, 721/11966, 721/11866, 721/11868, 721/12106 Chassis, Harness, machines over 10.5m lift height - 721/11881, 721/11882 Chassis
h3	Harness, machines upto 10.5m lift height - 721/11867, 721/11869 Panel Harness, machines over 10.5m lift height - 721/11880, 721/11883 Panel

Note: *For harness drawings see* ***Section C, Electrics****.*

Connectors (h1)

CA	Electronic control unit (ECU)
CB	Relay - grid heater
CC	Ambient air temperature sensor
CD	h1 - h2

Connectors (h2)

CP/CV	h2 - h3
DJ	h2 - h1
NK	Earth point - chassis

Connectors (h3)

CA	h3 - h2
EC	Ignition switch
DH	Warning light - side console

Splices (h2)

SB

SH

Splices (h3)

SS

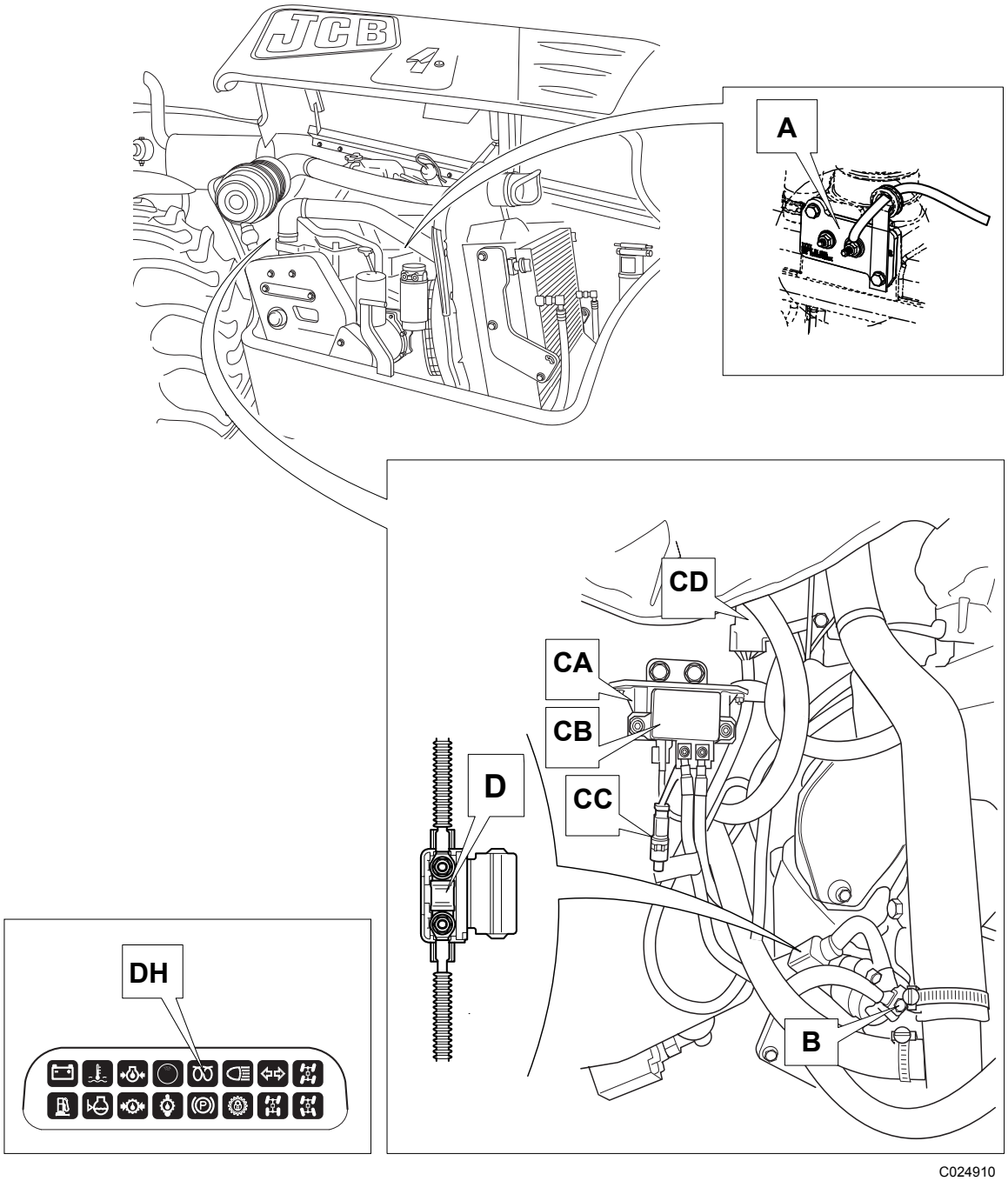


Fig 3. Components and Connector Locations

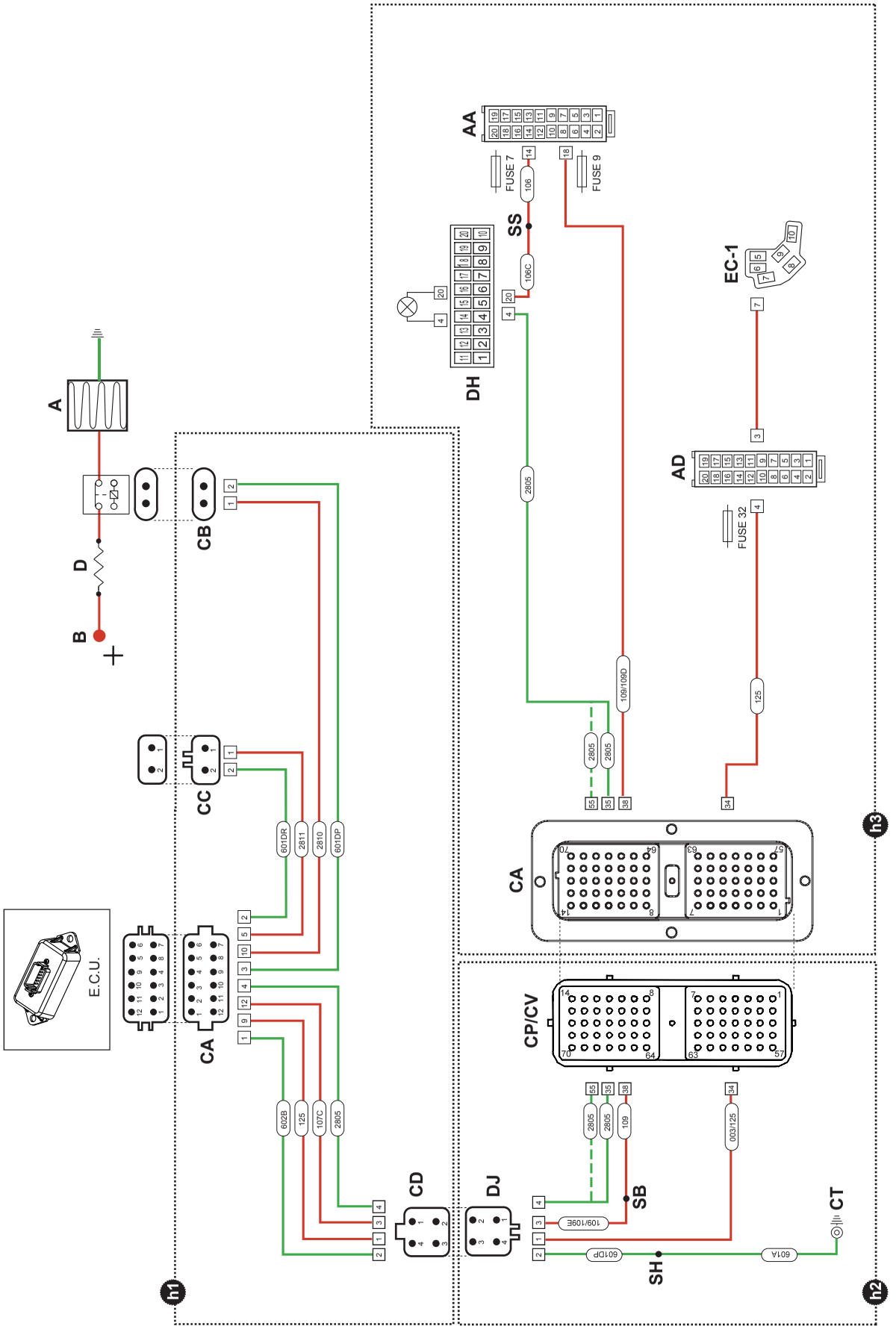


Fig 4. Wires and Connectors

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Cooling Pack

Removal and Replacement

Machines with Non-Intercooled Engines

The engine cooling pack is designed as a sub assembly which includes these components:

⇨ *Fig 6. (K-11)*

- **A** Engine coolant radiator matrix
- **A1** Radiator top hose connection
- **A2** Radiator bottom hose connection
- **B** Cooling fan and hydraulic motor assembly
- **C** Air conditioning condenser matrix and receiver drier (if fitted) ⇨ *Fig 5. (K-9)*
- **D** Hydraulic hoses - hydraulic fan motor
- **E** Solenoid valve - reversible fan (if fitted)
- F Transmission liquid to liquid oil cooler
- **G** Transmission oil cooler hoses
- H Transmission oil temperature sender
- J Cooling fan shroud
- **K** Anti recirculation air baffles
- L Air filter inlet hose connection
- M Fixing points
- **N** Fuel sedimentor
- **P** Hydraulic oil cooler (if fitted)

Although it is possible to remove individual components it is quicker and easier to remove the complete sub assembly, particularly if access is necessary for engine overhaul or removal and replacement for example.

Removal

⚠ WARNING

The air conditioning system is a closed loop system and contains pressurised refrigerant. No part of the system should be disconnected until the system has been discharged by a refrigeration engineer or a suitably trained person. You can be severely frostbitten or injured by escaping refrigerant.

4-3-4-1_2

Park the machine and make it safe. Obey the care and safety procedures. See ***Section 2 - General Procedures***

Important: *For some service procedures it is possible to remove the air conditioning condenser and receiver drier (if fitted) without disconnecting the hoses, thus it is not necessary to discharge the system. Make sure to support the condenser safely. If air conditioning hoses are to be disconnected make sure that the air conditioning system is discharged by an approved person. See* ***Section B - Air Conditioning****.*

1 Disconnect the air conditioning hoses at **5-A** and **5-B**.

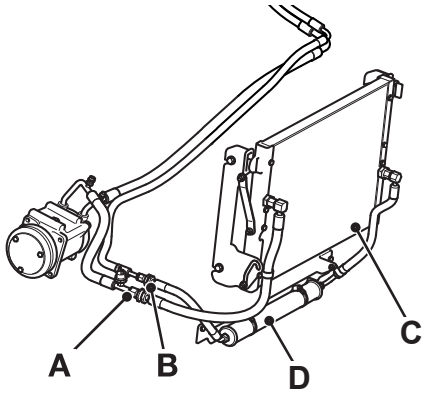

Fig 5.

Before trying to remove the cooling pack let the engine and hydraulic system cool.

1 Remove the engine cover and side pod assembly, see ***Section B - Access Panels***.

2 Disconnect the electrical connector at the transmission oil temperature sender **H**.

3 Put a label on the fuel lines, hoses and electrical connectors to help identification when replacing.

4 Disconnect the fuel lines and electrical connector at the sedimentor **N** or undo the sedimentor bolts and fuel line clips and tie the assembly safely out of the way.

5 Drain the engine coolant by disconnecting the radiator bottom hose at **A2**.

6 Disconnect the radiator top hose at **A1**.

7 Disconnect the fan motor hydraulic hoses **D** at the chassis. Seal all open hoses and pipes to prevent dirt going into the system.

8 Disconnect the electrical connector at the fan motor control valve **E** (if fitted).

9 Disconnect transmission cooler hoses **G** at the chassis. Seal all open hoses and pipes to prevent dirt going into the system.

10 Disconnect the air inlet hose at **L**.

11 Support the cooling pack assembly.

12 Remove bolts from positions **M** and carefully lift the assembly away from the machine.

Replacement

Replacement is the opposite of the removal procedure.

During the replacement procedure do this work also.

- After replacement fill the engine cooling system with the correct coolant. See ***Section 3 - Engine***
- Operate the engine and do a check of the fan motor speed.
- Do a check of the hydraulic fluid level. See ***Section 3 - Hydraulics***
- Do a check of the transmission oil level and top up as necessary. See ***Section 3 - Transmission***.

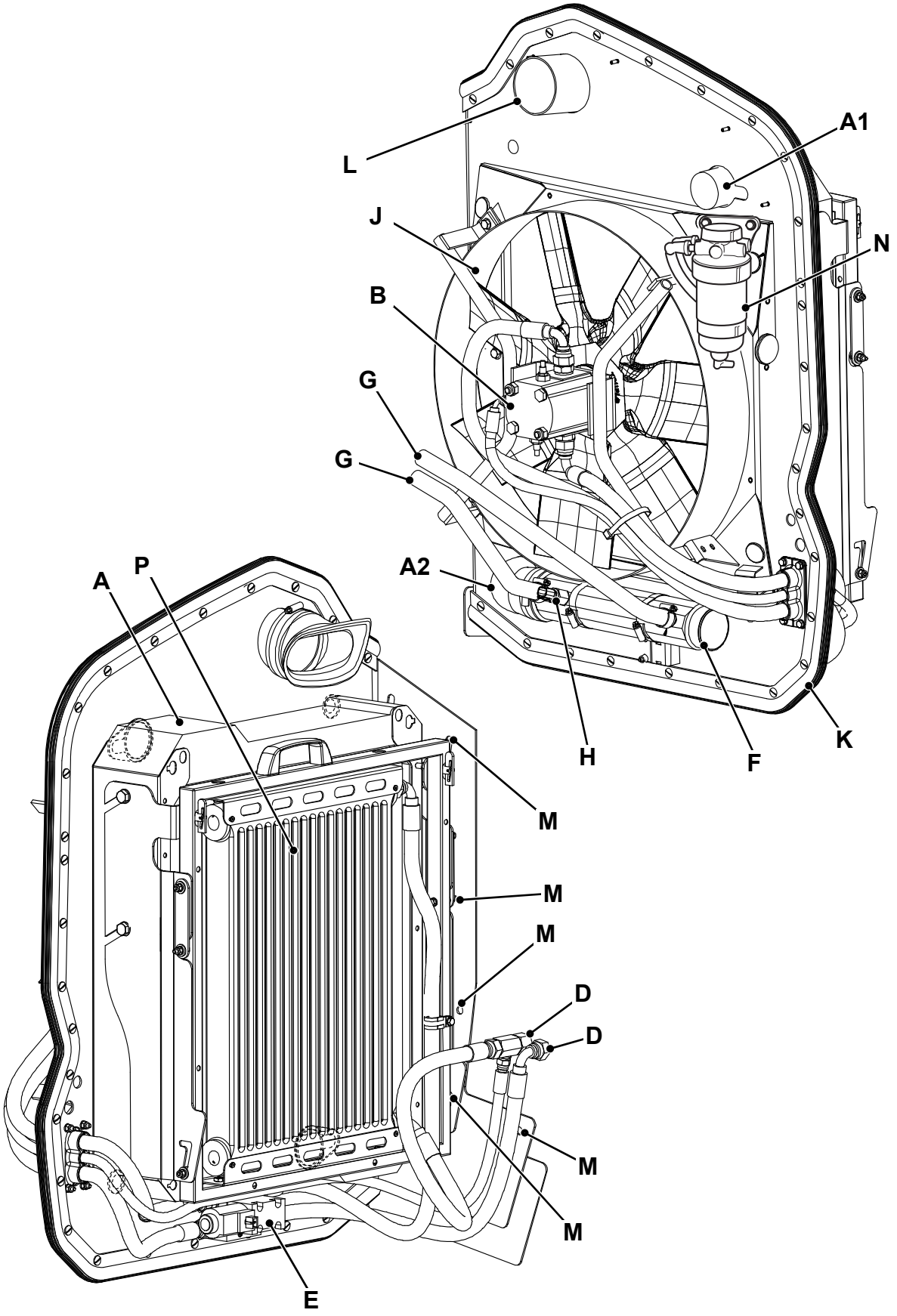

Fig 6. Cooling Pack, Machines with Non-Intercooled Engines up to Serial Number 1441999

Machines with Intercooled Engines

The engine cooling pack is designed as a sub assembly which includes these components:

⇨ *Fig 7. (K-14)*

A	Engine coolant radiator matrix(1)
A1	Radiator top hose connection
A2	Radiator bottom hose connection
B	Cooling fan and hydraulic motor assembly
C	Air to air intercooler matrix(1)
C1	Intercooler inlet hose connection
C2	Intercooler outlet hose connection
D	Hydraulic hoses - hydraulic fan motor
E	Solenoid valve - reversible fan (if fitted)
F	Hydraulic oil cooler matrix (if fitted)
G	Transmission air blast oil cooler matrix(1)
J	Transmission oil cooler hoses
K	Cooling fan shroud
L	Anti recirculation air baffles
M	Air filter inlet hose connection
N	Fixing points
P	Fuel sedimentor

(1) The engine coolant radiator, transmission oil cooler and air to air intercooler matrix are all integral. If any part of the assembly has failed the complete unit must be renewed.

Although it is possible to remove individual components it is quicker and easier to remove the complete sub assembly, particularly if access is necessary for engine overhaul or removal and replacement for example.

Removal

Park the machine and make it safe. Obey the care and safety procedures. See ***Section 2 - General Procedures***

Important: *For some service procedures it is possible to remove the air conditioning condenser and receiver drier (if fitted) without disconnecting the hoses, thus it is not necessary to discharge the system. Make sure to support the condenser safely. If air conditioning hoses are to be disconnected make sure that the air conditioning system is discharged by an approved person. See* ***Section B - Air Conditioning****.*

Before trying to remove the cooling pack let the engine and hydraulic system cool.

1 Remove the engine cover and side pod assembly, see ***Section B*** **- Access Panels**.

2 Put a label on the fuel lines, hoses and electrical connectors to help identification when replacing.

3 Disconnect the fuel lines and electrical connector at the sedimentor **P** or undo the sedimentor bolts and fuel line clips and tie the assembly safely out of the way.

4 Drain the engine coolant by disconnecting the radiator bottom hose at **A2**.

5 Disconnect the radiator top hose at **A1**.

6 Label and disconnect the fan motor hydraulic hoses **D** at the chassis. Seal all open hoses and pipes to prevent dirt going into the system.

7 Disconnect the electrical connector at the fan motor control valve **E** (if fitted).

8 Disconnect transmission cooler hoses **J** at the chassis. Cap all open hoses and pipes.

9 Disconnect intercooler hoses at positions **C1** and **C2**.

10 Disconnect the air inlet hose at **M**.

11 Support the cooling pack assembly, unscrew bolts from positions **N** and carefully lift the assembly away from the machine.

Replacement

Replacement is the opposite of the removal procedure.

During the replacement procedure do this work also.

– After replacement fill the engine cooling system with the correct coolant. See ***Section 3 - Engine***
– Operate the engine and do a check of the fan motor speed.
– Do a check of the hydraulic fluid level. See ***Section 3 - Hydraulics***
– Do a check of the transmission oil level and top up as necessary. See ***Section 3 - Transmission***.

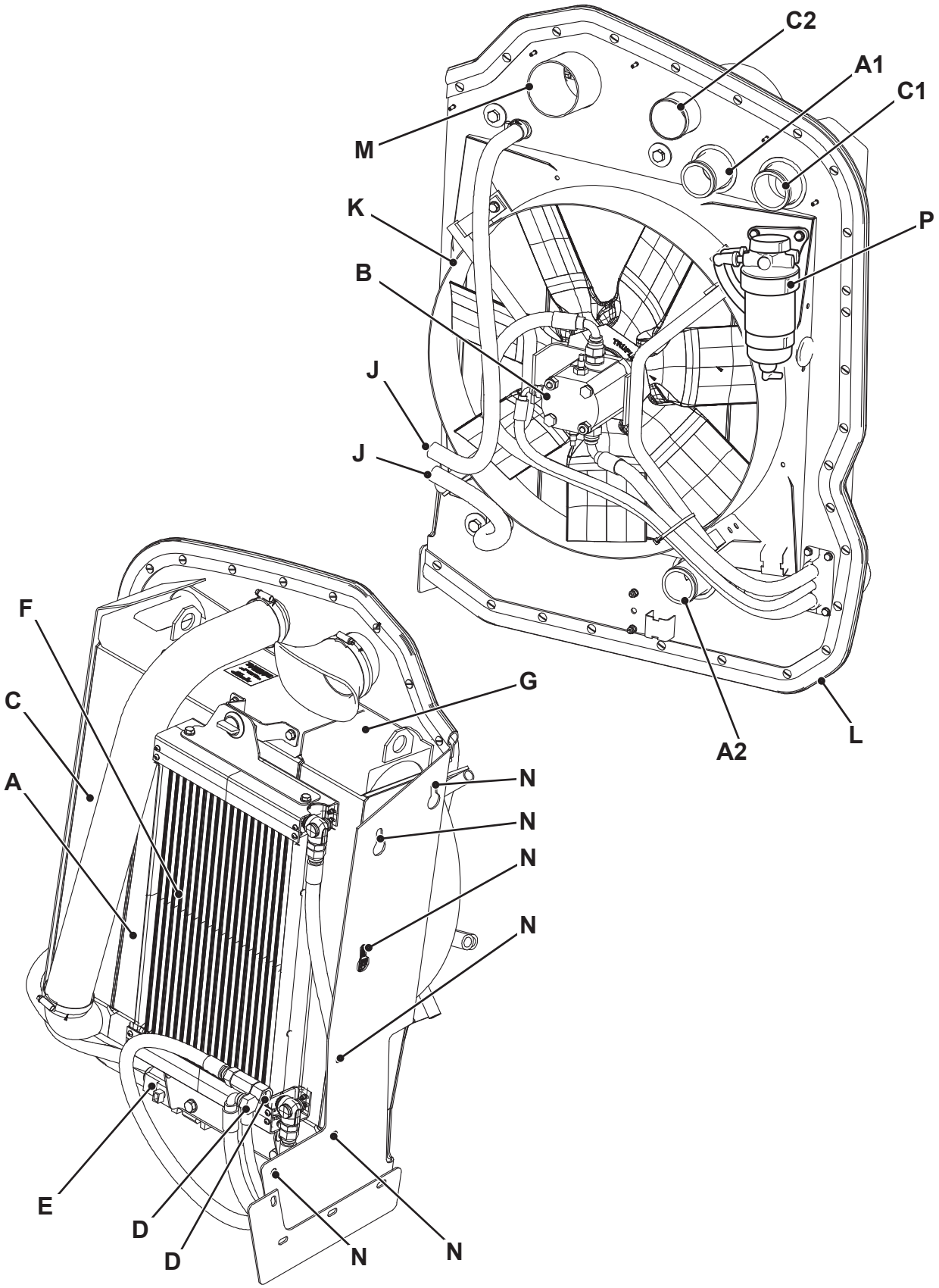

Fig 7. Cooling Pack, Machines with Intercooled Engines up to Serial Number 1441999 (Excluding Machines with SE Engines)

Dismantle and Assemble

With the cooling pack removed from the machine dismantle components as necessary. For cooling fan motor removal and replacement, dismantling and assembly procedure see ***Section E - Fan Motor***.

Coolant Expansion Tank

Removal and Replacement

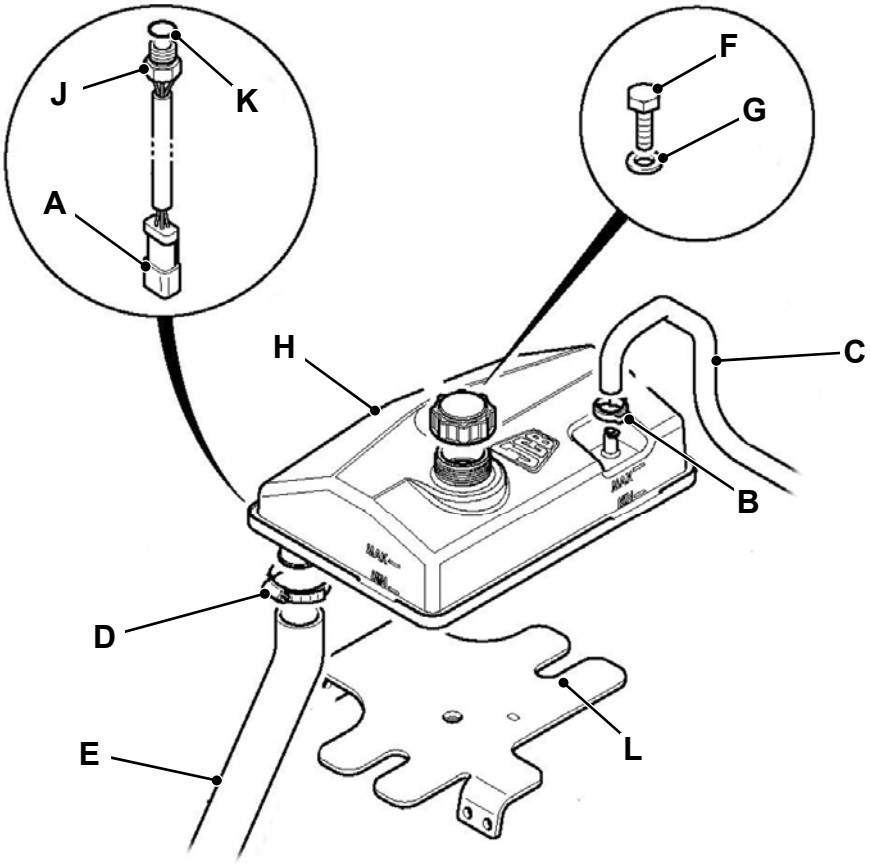

Fig 8.

Removal

1 Make sure that the engine cannot be started.

2 If the engine is hot let it cool for one hour.

3 Open the engine cover.

4 Drain the engine coolant. Refer to ***Section 3 - Routine Maintenance***.

5 Disconnect the coolant level sensor electrical connector **8-A**.

6 Release the hose clip **8-B** and remove the hose **8-C** at the expansion tank.

7 Release the hose clip **8-D** and remove the hose **8-E** at the expansion tank.

8 Remove bolt **8-F** from the centre of the expansion tank.

9 Lift off the expansion tank **8-H**. Remove washer **8-G**.

Replacement

Replacement is the opposite of the removal procedure. During the replacement procedure do this work also:

- Engage the tank correctly with the mounting plate **8-L**.
- Torque tighten bolt **8-F**.⇨ *Table 1. Torque Settings (K-17)*.
- Fill the engine cooling system with the correct type of coolant. Refer to ***Section 3 - Routine Maintenance***.
- When the replacement procedure is complete start the engine and check for coolant leaks.

Table 1. Torque Settings

Item	Nm	lbf ft	kgf m
8F	25	18	2.5

Coolant Level Sensor

Removal

1 Access to the coolant level sensor is limited. Drain the engine coolant and remove the coolant expansion tank from the machine, see ***Coolant Expansion Tank - Removal and Replacement***.

2 ⇒ *Fig 8. (K-16)*. Carefully unscrew the coolant level sensor **J** from the tank.

Replacement

Replacement is a reversal of the removal sequence, but note the following:

The coolant level sensor is a non-serviceable part. If the sensor is suspected as being faulty, it must be renewed as a complete assembly.

Renew the O-ring **K**.

Torque tighten the coolant level sensor **J**.

Table 2. Torque Settings

Item	Nm	lbf ft	kgf m
J (1)	1.4 - 2.7	1 - 2	0.14 - 0.27

(1) DO NOT tighten more than 1/6 of a turn beyond that required to seat the sensor against the surface of the tank. Over tightening of the sensor can lead to water ingress into the sensor.

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Vacuum Switch

Removal and Replacement

Removal

1 Make sure that the engine cannot be started.

2 Open the engine cover.

3 Disconnect the electrical connector from the switch **9-A**.

4 Loosen clip **9-C** and remove the induction hose **9-B** from the air filter assembly.

5 Turn the switch **9-A** counter-clockwise with your hand. Remove the switch.

6 Remove the adapter **9-D** and seal **9-E**.

Replacement

Replacement is the opposite of the removal procedure.

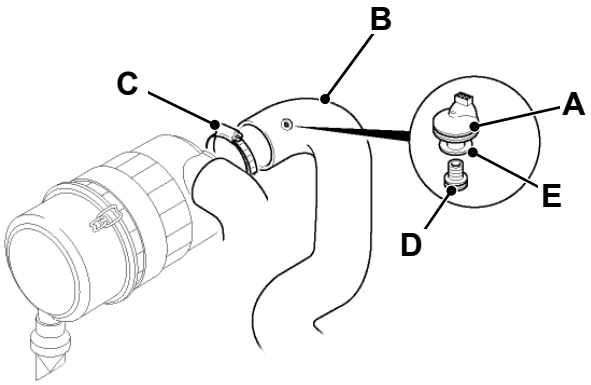

Fig 9.

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Silencer

Removal and Replacement

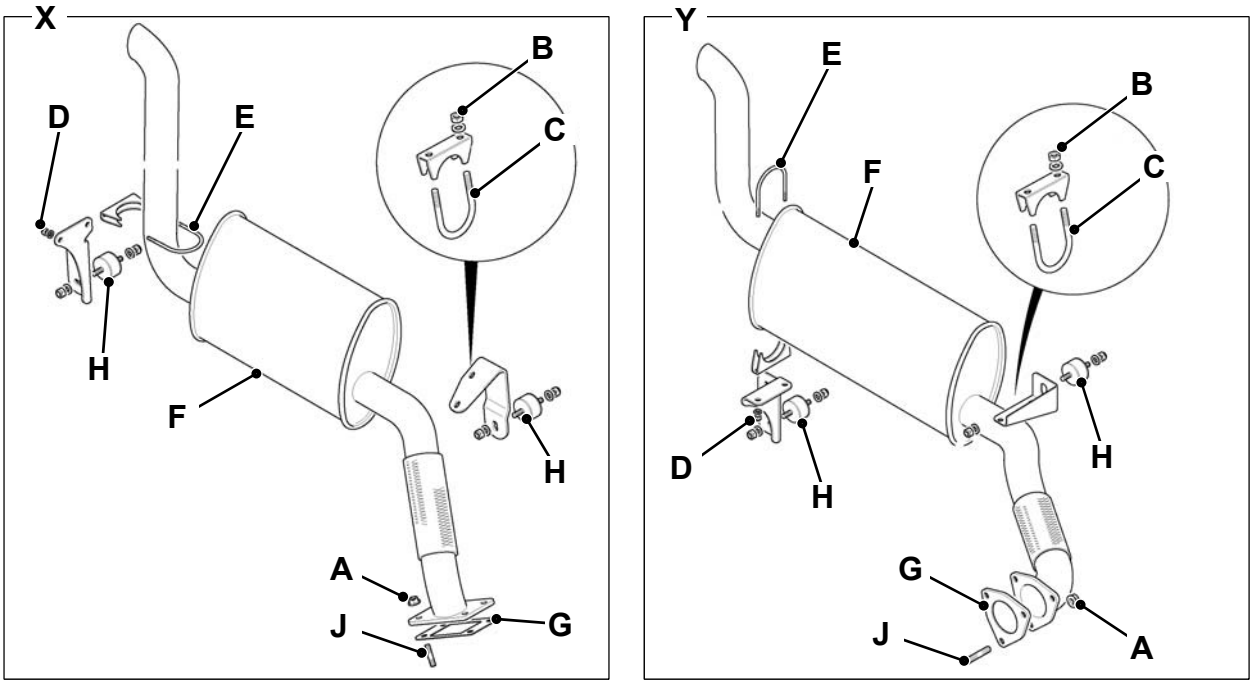

Fig 10.

Note: *The silencer assembly on naturally aspirated and turbocharged engines is different. The removal and replacement procedure is the same for both types.*

10X Silencer assembly - Naturally aspirated engines

10Y Silencer assembly - Turbocharged engines

Table 3. Torque Settings

Item	Nm	kgf m	lbf ft
10-A	22 - 26	2.2 - 2.6	16 - 19

Removal

1 Make sure that the engine cannot be started.

2 If the engine is hot let it cool for one hour.

3 Open the engine cover.

4 Remove the nuts **10-A**.

5 Remove the two nuts **10-B** and clamp assembly **10-C**.

6 Support the silencer **10-F**. Remove the two nuts 10**D** and clamp assembly **10-E**.

7 Lift off the silencer **10-F**.

8 Remove and discard gasket **10-G**.

9 Examine the rubber mounts **10-H**. If they are defective replace them with new ones.

10 Examine the studs **10-J** on the engine exhaust manifold. If they are defective replace them with new ones.

Replacement

Note: *Do not use a defective silencer. If the silencer is defective replace it with a new one.*

Replacement is the opposite of the removal procedure. During the replacement procedure do this work also:

– Use a new gasket **10-G**.
– Torque tighten the nuts **10-A**. ⇨ *Table 3. Torque Settings (K-22)*.

Removal and Replacement

Machines with SA,SB,SC Engines

Introduction

The engine and gearbox must be removed from the machine as a complete unit. The total weight of the engine and gearbox assembly is approximately 1000 kg. A suitable overhead crane and lifting frame will be required to safely lift and manoeuvre the assembly in and out of the machine chassis. The following procedures describe removing and replacing the engine and gearbox as a complete unit. Before separating the engine and bevel box. ⇨ ***Separating the Engine and Bevel Box (K-28)***.

⇨ ***Fig 11. (K-26)***

Note: *The following component identification is for a typical engine installation.There will be some component differences depending on the machine variant.*

A Lifting bracket - front
B Lifting bracket - rear
C Lifting bracket fixing bolts
D Electrical connection - cold start heater (if fitted)
E Electrical connection - starter motor
F Electrical connector - engine electrical harness
G Electrical connection - earth strap
H Fuel line connector - return to tank line
J Hose connection - cab heater
K Exhaust silencer connection
L Engine and gearbox mountings
M Throttle cable
N Hydraulic pump
P Hose connection - brake vacuum
R Breather hose - bevel gearbox
S Support stands
T Hose connections - air conditioning compressor (if fitted)
U Electrical connector - gearbox
V Propshaft couplings - gearbox
W Hydraulic hose connections - gearbox remote filter (if fitted)
X Park brake cable
Y Ties - electrical harnesses

Removal

Note: *The following procedures are for a typical engine and gearbox installation. There will be some procedural differences dependant on machine variant. Before attempting to remove the engine and gearbox ensure that all the necessary components have either been removed, or safely disconnected.*

⚠ WARNING

Make the machine safe before working underneath it. Park the machine on level ground, lower the attachments to the ground. Apply the park brake, put the transmission in neutral and stop the engine. Block both sides of all four wheels.

Disconnect the battery, to prevent the engine being started while you are beneath the machine.

GEN-4-1_1

Machines with Air Conditioning

1 Discharge the air conditioning system and disconnect the hoses **T** at the compressor. See ***Section B***.

⚠ WARNING

The air conditioning system is a closed loop system and contains pressurised refrigerant. No part of the system should be disconnected until the system has been discharged by a refrigeration engineer or a suitably trained person. You can be severely frostbitten or injured by escaping refrigerant.

4-3-4-1_2

All Machines

1 Remove the engine cover and side pod, see ***Section B - Access Panels***.

2 Remove the cooling pack, see ***Cooling Pack***.

3 Remove the cooling system header tank.

4 Disconnect the following at the engine:

- **a** Throttle cable **M**.
- **b** Fuel leak-off pipe **H**.
- **c** Heater hose.
- **d** Brake servo vacuum hose **P**.
- **e** Cold start heater electrical cable **D** (if fitted).

5 Uncouple the engine electrical harness connector **F**.

6 Disconnect exhaust from the manifold **K** and detach from chassis side plate. Remove the exhaust silencer assembly.

7 Disconnect the parking brake cable **X** at the brake caliper or gearbox as applicable. See ***Section G***.

Note: *The illustration shows a disc type parking brake. Some machines are fitted with an integral type brake.*

8 Disconnect the front and rear propshafts at the gearbox. **V**.

9 Drain the hydraulic tank.

10 Label and disconnect the pipe and hose connections to the hydraulic pump **N**. See ***Section E***.

11 Disconnect the gearbox hydraulic remote filter hoses **W** (if fitted)

12 Uncouple the gearbox electrical connector **U**.

13 Undo the transmission oil cooler pipe fixing on the chassis (not shown).

14 Make sure that all the relevant hoses pipes and wiring have been disconnected and tied away from the transmission assembly.

15 Attach a specially fabricated lifting beam to engine and transmission assembly. Using suitable lifting equipment take the weight of the engine and transmission assembly (approx. 1000 kg).

Important: *Do not attempt to lift the engine and transmission assembly using the engine lifting brackets. The brackets are designed to lift the engine only.*

Note: *The tool (lifting beam) is designed specifically to lift the side mounted engine, bevel box and Powershift transmission as a complete assembly. Refer to* ***Section 1 - Service Tools, Section K - Engine****, for details of manufacture and conditions of use.*

Important: *The tool (lifting beam) is not to be used to lift the engine on its own, any other part of the machine or for any other lifting duty or use.*

16 Place suitable engine support stands **S** under the engine and gearbox. DO NOT place support stands under the engine sump.

17 Undo and remove the three transmission mounting bolts **L**. Make sure that the assembly is safely supported by the lifting equipment and then remove the stands.

18 Lower and withdraw the assembly from the machine.

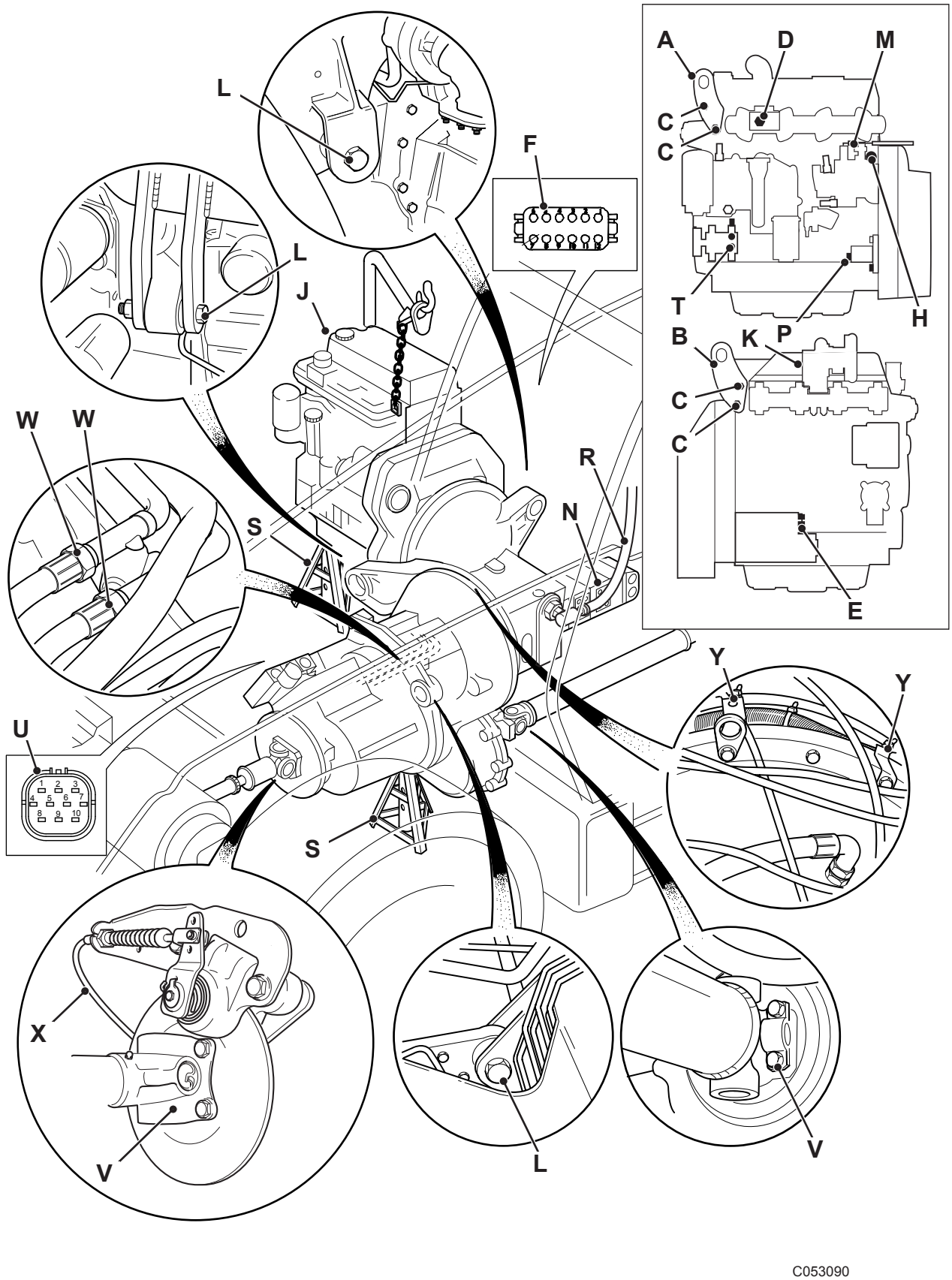

Fig 11.

Replacement

Replacement is a reversal of Removal.

If coolant hoses have been removed during the engine dismantle and assembly procedures, refit the hoses. Push the hose **12-A** on in the position shown. Do not push the hose past the location stop **12-B**.

Replenish oil and water levels on completion.

Adjust the parking brake as required.

Table 4. Torque Settings

Item	Nm	kgf m	lbf ft
L	118	12	87

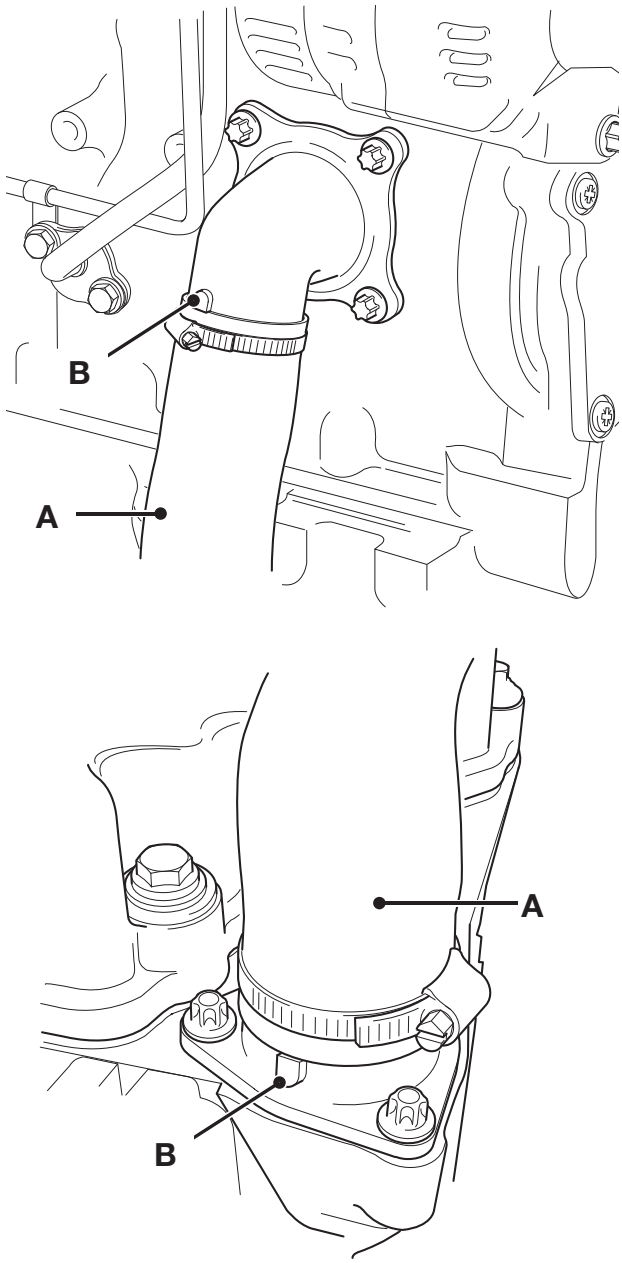

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Fig 12.

Separating the Engine and Bevel Box

Note: *The following procedures are for a typical engine and gearbox installation. There will be some procedural differences dependant on machine variant. Before attempting to remove the engine and gearbox ensure that all the necessary components have either been removed, or safely disconnected.*

Dismantling

The engine, bevel box and transmission should be removed from the machine as one complete unit before carrying out the following procedure. ⇨ *Removal (K-24)*.

1 Using appropriate lifting equipment attached to the engine lifting brackets, support the weight of the engine. The equipment must be capable of lifting 600 kg (1320 lb).

Check the lifting brackets for damage and security before the engine is lifted. The correct torque for the lifting bracket setscrews is 44 Nm (33 lbf ft).

Note: *The lifting equipment must be arranged so that it provides a vertical lift directly above each of the two lifting brackets, as shown at **13-A**, ensuring that there is a clearance between the hooks and the rocker cover to avoid damage to the engine. Never use a single bracket to raise an engine.*

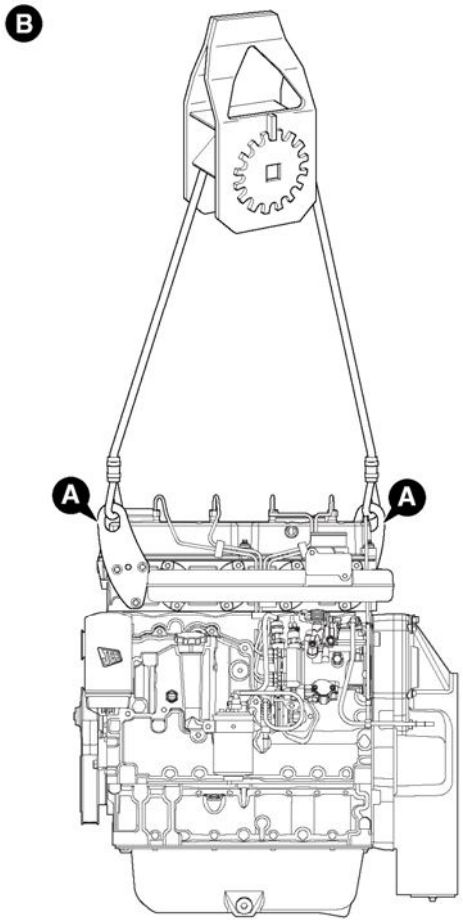

Fig 13.

2 Remove bell housing bolts **14-A**.

Note: *The bolts **14-A** are sized to suit their positions. Bell housing bolts must be replaced in the same positions.*

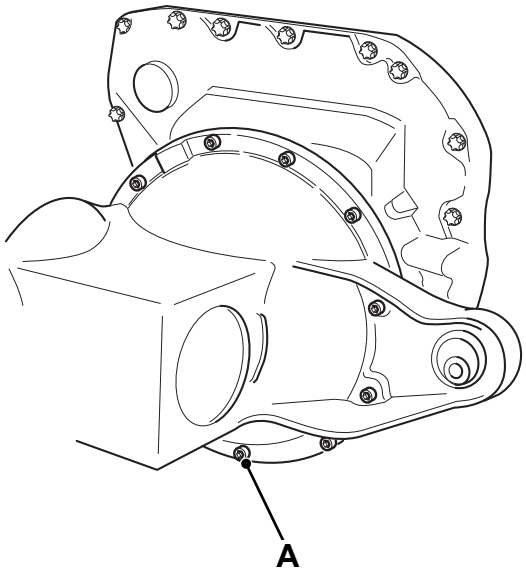

Fig 14.

3 Carefully draw the engine away from the transmission. Be careful not to put any side force on the transmission input shaft. Lift the engine clear of the machine.

4 Place the engine on a suitable stand.

Assembly

Assembly is the reverse of Dismantling.

If the damper **15-A** has been removed, clean the mating faces with a clean, dry cloth. The damper can be fitted in any position as it is balanced individually.

Apply JCB Activator and JCB Threadlocker and Sealer to the 6 bolts **15-B**.

Torque tighten the 6 bolts **15-B**. ⇨ *Table 5. Torque Settings (K-29)*.

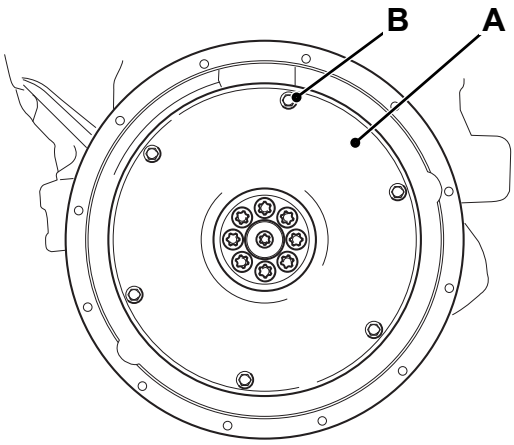

Fig 15.

Apply locking fluid and torque tighten bolts **14-A**, making sure the bolts are fitted in the correct position, as marked during removal.

Table 5. Torque Settings

Item	Nm	kgf m	lbf ft
14-A	98	10	72
15-B	67 - 72	6.8 - 7.3	49 - 53

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